LAND AT UPPER COSMESTON FARM, LAVERNOCK ROAD, PENARTH

ENVIRONMENTAL STATEMENT

VOLUME 2
CHAPTER 9: GROUND CONDITIONS

9.0 GROUND CONDITIONS

INTRODUCTION

9.1.1 The purpose of this chapter is to provide an understanding of the baseline physical environment on and adjoining the proposed development site (including designated sites, topography and land stability, soils, geology, groundwater, and potential historic contamination) to consider the possible direct or indirect effects that construction, and use of the proposed development could have on this environment; and to detail methods by which these potential impacts can be mitigated.

9.1.2 The Earth Science Partnership Ltd. (ESP) were instructed by Austin-Smith: Lord on behalf of the Welsh Government to undertake an integrated geotechnical and geo-environmental investigation at the site, with the objective of the investigation, provided by the Client identified as, "To undertake a geoenvironmental ground investigation and associated interpretive reporting to inform the masterplan and drainage strategy for the development of the site at Cosmeston Farm, Penarth for residential housing and a proposed primary school".

9.1.3 At the time of investigation ESP understood the proposed masterplan will include residential housing, a 2 Form Entry Primary school, community space, public open space and associated areas of access roads, hardstanding and landscaping. This Chapter provides a summary of the conditions encountered and full reference should be made to ESP report (Ref: 7061b.3166 Rev2) for full content and context. The ESP Report is provided at Volume 3, Appendix 9.1.

APPROACH AND ASSESSMENT METHODOLOGY

Baseline

9.2 The baseline information has been compiled from the following sources of information:

- British Geological Survey Data;
  - Published solid and drift geological maps;
  - Borehole logs;
  - Physical Ground Investigation Information;

- Environment Agency Data;
  - Source Protection Zone Maps;
  - Groundwater Vulnerability Maps.

Methodology

9.3 This assessment included a third party report review and investigation and assessment work undertaken in general accordance to Eurocode EC7, BS5930:2015, BS10175:2013, BS8485:2015, BRE365:2016 and CIRIA C552:2001 (Contaminated Land Risk Assessment).

Soils and Geology

9.3.1 The main impacts associated with this development are associated with potentially contaminated soils, i.e. the impact of contaminated soils upon the proposed development, and the possibility of the construction and occupation of the proposed development causing ground contamination. However, this assessment has not focussed solely upon these issues.

9.3.2 In determining the potential impacts upon the proposed development from contaminated soils a combination of qualitative and quantitative assessment, using the 'source – pathway – receptor' approach, has been undertaken to determine the potential risks posed to construction workers, buildings and end users of the proposed development.

9.3.3 The assessment has sought to identify whether the impact is beneficial or adverse, direct or indirect, permanent or temporary, and short term, medium term or long term, based on no mitigation measures being implemented.

Hydrogeology

9.3.4 The potential impacts to water resources have been assessed in a qualitative manner. This is due to the difficulties in assigning any value to the impacts which could potentially occur from the proposed development. As a result a descriptive identification and assessment of impacts has been carried out.

9.3.5 For potential environmental risks considered, the methodology set out in CIRIA C552 (2001), Contaminated Land Risk Assessment – A Guide to Good Practice, has been used to assess whether or not risks are acceptable, and to determine the need for collating further information or remedial action. The tables have been used to classify the risk for each pathway. Attachment A, appended to this Chapter, through Tables A1 to A4 seeks to identify and quantify the Classification of Consequence (Table A1), the Classification of Probability (Table A2), the Comparison of Consequence Against Probability (Table A3) and the Description of Resultant Risk Categories (Table A4).

9.3.6 In addition to the risk driver tables adopted by ESP, and as required by this Chapter, an identification and assessment of impacts has been made with reference to the information within the reports listed above and the particular issues highlighted by them. This is interpreted using professional judgement and experience based on previous developments. A judgement has been made on the importance and/or sensitivity of the receptor(s) involved, as indicated below.

Table 1 Sensitivity of the Physical Environment

Receptor Sensitivity	Definitions
High	Designated sites, such as geological and groundwater SSSIs, RIGS and GCRs Areas of critical topography, including steep slopes and historic landslip locations Areas of existing mineral extraction (coal) and areas designated as Primary coal resources Zone 1 Groundwater Source Protection Zones Areas of high groundwater vulnerability Major aquifers Areas of known/confirmed contaminated land/groundwater Rivers with a Grade A water classification
Medium	Typical rural topography Area of Search for minerals and areas designated as Secondary or Tertiary coal resources Zone II and III Source Protection Zones Minor aquifers Areas with intermediate groundwater vulnerability Rivers with a Grade B water classification
Low	Industrial site topography Areas without known mineral resources Rivers with a Grade C or D water classification Non-aquifers Areas with low groundwater vulnerability

Magnitude of Change

9.3.7 A large magnitude change would be one that is likely to cause a direct adverse permanent or long-term impact on the integrity/value of the receptor whereas a small change would be one that is likely to have a minor adverse impact on a receptor but recovery is expected in the short term. The following gives examples of levels of magnitudes of change on the physical environment.

Table 2 Magnitude of Impact

Magnitude	Definitions
Large	Change is likely to cause a direct adverse permanent or long-term (more than 10 years) impact on the integrity/value of the receptor
Medium	Change is likely to impact adversely on the integrity/value of the receptor but recovery is predicted in the medium term (5-10 years) and there is predicted to be no permanent impact on its integrity
Small	Change is likely to adversely impact the integrity/value of the receptor but recovery is expected in the short term (1- 4 years) or is within the bounds of likely natural variation
Negligible	A change well within the bounds of natural variation. No effect detectable or recovery within a very short timescale (<1 year)

Assessment of Significance of Residual Effects

9.3.8 An assessment has been made of the significance of residual effects, i.e. those impacts that are predicted to remain after the mitigation measures have been implemented. The categories used when classifying overall significance are indicated below. In each case, the reasons for the judgements reached are stated.

Table 3 Significance of Residual Effects

		Sensitivity		
		High	**Medium**	**Low**
Magnitude of change	**Large**	Highly Significant	Moderately Significant	Slightly Significant
	Moderate	Moderately Significant	Slightly Significant	Not Significant
	Small	Slightly Significant	Not Significant	Not Significant
	Negligible	Not Significant	Not Significant	Not Significant

9.3.9 The magnitude of a potential impact is dependent on the importance of the feature and is estimated based on no mitigation measures being implemented. The significance of a specific potential impact is derived from both the importance of the feature and the magnitude of the impact.

9.3.10 Estimated residual impacts are based on the proposed mitigation measures being implemented.

9.3.11 Using the above assessment criteria, some issues may be identified as being "not significant" in terms of their environmental impact. However, it should be noted that, whilst they may be considered to be such, they may still result in a breach of legislation. Under the Water Resources Act 1991 it is an offence to cause or knowingly permit poisonous, noxious, or polluting matter, or any solid waste matter to enter controlled waters (which include rivers and groundwater). The Groundwater Regulations 1998 require the prevention of entry of List I substances (which includes hydrocarbons) to groundwater and to prevent List II substances from polluting groundwater. As such controls shall still be required to prevent the entry of substances to surface waters and groundwater.

ENVIRONMENTAL BASELINE

9.4 The following section contains a summary of the information presented in the ESP report and reference should be made to the ESP report (Ref: 7061b.3166 Rev2) for full content and context which is provided at Volume 3, Appendix 9.1.

Site Description

9.4.1 The site is located within the boundaries of Lower Cosmeston Farm, Cosmeston. Due to the overall size of the site and differing anticipated geologies and ground conditions, the site was split into five areas to ensure ease of discussion and clarity of information that was provided for each area of the site. The areas that the site was separated into were determined as:

- Area A – Comprising the West fields that make up the winter paddocks and fields associated with the livery;
- Area B – The historic former quarry/infilled land now used as summer paddocks;
- Area C – The historic former quarry and part of a former landfill;
- Area D – The North/North East fields that are currently used for crop growth.
- Area E - The "Old Quarry". This area was not accessible during the investigation, due to ecological constraints and no assessment was undertaken.

A walkover undertaken as part of pre-investigation attendance, noted a historic railway embankment trending roughly north east to south west through the central portion of the site and forming a boundary line between Areas B and Areas C and D. The remaining boundaries between the areas, generally comprise soft boundaries, such as hedgerows and trees. At the north of the site and noted adjoining Areas B and D, a vertical rock face is present, beyond which a residential housing estate is identified (see Figure 3).

The south part of Area B is used to store a number of materials, including fencing, signage, cones and metal containers. A number of other man made materials such as plastic tubs, cement, lubricants and tarmacadam products were stored directly on the ground along with bottles of propane gas bottles, farm machinery and fly tipped materials.

Anecdotal evidence from the farm tenant indicates that this area was also used as a pyre for cattle, during the foot and mouth outbreak of 2001.

9.4.2 Please refer to Figure 1 from the report which highlights the splitting of the site into Areas A to E.

Site History

9.4.3 A review of the site history presented within a third party Desk Study indicated that from the late 1800s the site was occupied by agricultural fields. By 1900, a railway was noted to roughly bisect the site (between Areas B, C and D). Between 1900 and 1920, a quarry was noted in the west of the site (Area B), with a small section of this quarry extending into Area C. Another small quarry was present in the north of the site (Area E). By 1940 the quarry excavations were noted to expand into Area C, whilst the quarries in Area B and Area E appeared to have been infilled. By 1965, the quarry in Area C was indicated to have been infilled. By 1970, the site appeared to have reverted back to agricultural land use, with no significant changes after this time. Whilst the railway was no longer indicated after around 1960, the embankment remained and has also been observed on site. Areas A and D predominantly remained agricultural fields throughout the available historical mapping, with no significant development and/or features identified.

Geology

9.4.4 The published 1:10,560 scale geological map for the area of the site (Sheet ST16NE) indicates the majority of the site to be underlain by the Jurassic St Marys Well Bay Formation bedrock. A limited area of Lavernock Shales (Jurassic) are identified in the south west of the site (Area A) and in the east of the site (Area D) the bedrock is noted to become the Triassic Group bedrocks comprising the Penarth Group. These rocks typically comprise interbedded mudstones and limestones. Limited superficial deposits are recorded, however, areas of Alluvium are noted at the western boundary (Area A) associated with the Sully Brook.

9.4.5 The published 1:50,000 scale geological map for the area of the site available on the website of the British Geological Survey, 2019) confirms this stratigraphy. Based on site history and the use of Areas B and C as quarries and landfill, a potentially significant cover of Made Ground is anticipated, with the Made Ground in Area C, likely to comprise highly variable and potentially contaminating domestic type landfill materials.

Hydrogeology

9.4.6 The bedrock underlying the site are classified as potential aquifers. The St Marys Well Bay Formation and Penarth Group are classified as Secondary A Aquifers, whilst the Lavernock Shales are classified as a Secondary B Aquifer. Secondary A Aquifers generally correspond with the previously classified minor aquifers, and comprise permeable layers capable of supporting water at a local, rather than strategic, scale and in some cases form an important base flow to rivers. Secondary A Aquifers are sensitive to pollution. Secondary B Aquifers generally correspond with the previously classified water bearing parts of non-aquifers and comprise strata of generally lower permeability, but which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. In some circumstances, Secondary B Aquifers can be sensitive to pollution.

Hydrology

9.4.7 The site is bordered by the Vale of Glamorgan coastline and the Severn Estuary with the associated cliffs forming the east boundary of Area D. The main surface water feature is the Sully Brook which flows in a south-west direction and is located 40m to the west boundary of the site, on the opposite side of Lavernock Road. Approximately 200m to the west, is Cosmeston Lakes, which comprise former, flooded, quarries, approximately 15Ha in size.

Archaeology

9.4.8 A full archaeological assessment was not included within ESP's brief, but we understand that areas of archaeological importance are present in Areas A and C, with all aspects of archaeological identification and protection being implemented by a third party. The areas of archaeological importance communicated to ESP, prior to site attendance and limited the investigation in some discrete areas of the site. The archaeological concerns at the site are discussed further in the Archaeological documents submitted in support of the application.

Ecology

9.4.9 A full ecological assessment was not included within ESP's brief, however, a number of areas of the whole site are ecologically sensitive. All aspects of ecology are being undertaken by a third party (The Environmental Dimension Partnership). All intrusive investigation have been implemented in line with their guidance email of 28th November 2018. The ecological concerns at the site restricted access to some areas and are discussed further in the Ecology Chapter of this document (Chapter 8).

Ground Gas and Radon

9.4.10 Radon is a colourless, odourless gas which is radioactive. It can occur naturally where uranium and radium are present in the underlying geology. It can migrate through cracks in the ground and enter spaces in dwellings.

9.4.11 Available information indicates the site is in an area where <1% of home are affected by Radon. Monitoring for general ground gases is ongoing to determine the risk posed by carbon dioxide, methane and hydrogen sulphide.

Contamination

9.4.12 A review of the site history and existing investigation information indicates that the site has been occupied by farmland since at least the late 1800s. Parts of the site (Areas B and C)have also been occupied by historic quarrying and landfill. From the available information, we consider that the following features on site could prove sources of diffuse and point source contamination that could impact on the development, environment or site users:

- Made Ground – general diffuse contamination (potential in all Areas);
- Made Ground – infilled quarry (Area B);
- Made Ground – landfill (Area C);
- Made Ground – historic railway that bisects Areas B and D.
- Made Ground – stockpiles of waste materials, fly tipping etc.
- Asbestos previously identified in work by Arcadis.
- Cattle Pyre in Area A.

Projected Baseline

9.4.13 The available pre-investigation information indicated that dependant on the area/zone, the site posed a moderate to high risk to the environment, Controlled Waters and Site End Users in its current form, with some areas of the site that are generally greenfield (A & D) posing a lower risk. Attachment B identifies the preliminary/plausible risk categories that were determined as part of the assessment.

Limitations

9.4.14 Baseline information was assessed through a review of the published information, the existing desk study and existing preliminary ground investigations

IMPACT ASSESSMENT

9.5 The most recent intrusive investigation performed by ESP was undertaken between 28th January and 21st February 2019 and comprised trial pitting, rotary openhole and rotary cored boreholes, cable percussion commencement boreholes, soakaway and falling head infiltration testing, geoenvironmental and geotechnical laboratory testing, gas and groundwater monitoring, monitoring and sampling of groundwater. Due to ecological, archaeological and other access restraints, some areas of the site were not investigated and

this is documented full in our report (Ref: 7061b.3166 Rev2). As part of these works, an inspection of the cliff line that forms the east boundary of the site has also been undertaken.

Soils and Geology

9.5.1 The exploratory holes undertaken across the site, have identified a variable ground model within the different areas of the site and these were recorded as follows. It should be noted that the below provides a summary of the ground conditions only and full reference should be made to our report (Ref: 7061b.3166 Rev2) for detailed descriptions of each strata. The ground conditions and typical depths encountered are summarised in Table 1 below and the locations of exploratory holes are shown on the appended Exploratory Hole Location Plan.

Table 1: Ground Conditions Encountered

Strata	Area A (Fields)	Area B (Infilled Quarry)	Area C (Landfill)	Area D (Fields)
Topsoil	0.2 – 0.3m	(Placed Topsoil) 0.25m	(Placed Topsoil) 0.2m	0.2 – 0.45m
Made Ground	n/a	5.5 – 9m	0.5m	n/a
Landfill	n/a	n/a	7m	n/a
Bedrock (St Marys Well Bay)	From 0.3m	From 5.5 to 9m	From around 7m	From 0.5m
Bedrock (Probable Penarth Group)	n/a	n/a	n/a	From 0.5m

9.5.2 The development of the site is proposed from the current agricultural land-use to a residential land-use. The following assessment describes potential impacts involved with the development of the site. The most sensitive on and off site receptors are considered to be water resources, uncontaminated soils and end users.

Construction Phase

9.5.3 The construction phase will essentially comprise earthworks which are required to be undertaken to create development platforms through a cut/fill operation and groundworks for the actual construction operations.

9.5.4 All stages of the construction phase will involve moving or stationary plant and equipment, which may impact site soils. These impacts are mainly associated with spills and drips or accidental releases of hazardous substances during operation, storage or re-fuelling of plant and equipment. Additionally, the potential exists for spills and drips to occur associated with stored chemicals brought onto the site to facilitate development. The release of these materials to the soil environment may result in soils being contaminated. It is therefore considered that temporary adverse impacts on the site soils, of major significance, could potentially occur through poor site practices.

9.5.5 Vehicles tracking over soils have the potential to spread this contamination and carry it off-site. The potential impact of vehicles tracking over the site is a temporary adverse impact of moderate significance, as contaminants may be deposited on uncontaminated site soils.

9.5.6 The excavation and disturbance of the soils during cut and fill works, may lead to a number of impacts primarily associated with soils. Additionally the construction of hardstanding areas and building of foundations may lead to a number of impacts primarily associated with contaminated soils.

9.5.7 Disturbance of soils may alter the chemical conditions within the site soils resulting in mobilisation of potential contaminants. The migration of mobilised contaminants has the potential to have a direct, moderately significant impact on the uncontaminated site soils and construction workers over a long timescale.

9.5.8 Arisings from the excavation of soil for foundations will potentially result in the stockpiling of soils on the site. Dependant on the area of the site from which the soils are excavated, there is a potential for contaminant mobilisation.

9.5.9 Should during the construction phase any contaminated soils be identified and the subsequent treatment or offsite disposal of contaminated soils, is required, this will result in the permanent removal of some contaminated soils. The impact of the removal of contaminated soils from the site is a beneficial impact, which is direct and long term.

9.5.10 Excavation may encounter perched water bodies and necessitate local dewatering to maintain a dry operational area. If not properly contained, contaminants from the water may leak into the underlying ground. Temporary adverse impacts of moderate significance could potentially occur to underlying strata due to contaminated water potentially leaking from pipelines / storage tanks.

Post Development Phase

9.5.11 Potential longer term impacts of the redevelopment are considered to occur both as a consequence of changes to the site's character and also future use of the redevelopment.

9.5.12 It is not considered that the proposed residential development will have any continuing effect on geology.

9.5.13 Sulphate, which can aggressively attack building materials and structures, may be present at the site. The potential impact of chemical attack on building materials is considered to be a direct impact of minor significance that may occur over a long timescale.

9.5.13 There is also the minor potential for contaminants to migrate along service trenches to uncontaminated soils. The potential migration of contaminants off site is considered to be a long term adverse impact of moderate significance.

Hydrogeology

9.5.14 Groundwater resources can be impacted by either changes in levels, flows or by changes in quality.

9.5.15 The investigation did not identify any groundwater during the undertaking of exploratory works. However, the exploratory holes were completed within one working day and due to

the soils low permeability, it is possible that groundwater may be present within the depth of investigation, but there was insufficient time for it to be recorded. No obvious groundwater strikes were recorded during the construction of boreholes.

A review of the groundwater levels obtained during the groundwater monitoring exercise (see ESP Controlled Waters Risk Assessment –Appendix 9.2) indicate groundwater to generally flow toward the west, from Area D through Area C and Area B to Area A where it is at its lowest, of around 11mOD. The groundwater monitoring suggests that a single continuous body of water has been measured below the site, variations in this body of water are discussed below.

The monitoring of shallow installations within Area B has generally shown that there is no persistent groundwater body within the reworked material. Groundwater has been measured in the deeper monitoring installations and suggest that groundwater is below the depth of Made Ground in this area. The former quarry is likely to act as a sink, or drain for groundwater and no lining was identified in the boreholes. It would in parts perhaps contain isolated pockets of water, but the monitoring has shown water to not be held within it and it may therefore allow water to pass through it freely.

The monitoring within Area C has shown that the groundwater level in both the shallow and deep installations are at a similar level, suggesting that any water within the landfill materials are directly connected to the general groundwater in the area. No clay or other type of lining was noted in the base of the landfill, groundwater would therefore be able to flow/pass through the base of the landfill unhindered into the underlying bedrock and evidence of this has been seen in the monitoring.

The investigation has not been able to ascertain the groundwater levels within the wider landfill area off site. It is reasonable to assume, based upon our findings, that the whole of the former landfill is unlined and any water (and contamination) within it, is directly connected to groundwater, as indicated by our monitoring. The whole landfill in this instance will be acting as a 'bowl' or 'colander' as water will collect within it and form a preferential drainage pathway for water to flow into it, but it will also allow groundwater to seep directly into the underlying strata. As such, it is possible that contaminants may be flowing out of the landfill in other areas, i.e. not just from Area C investigated but the wider landfill to the south of Area C.

Contamination

9.5.16 The most sensitive on site receptors are considered to be the underlying Secondary A and B aquifers and the off-site Sully Brook.

9.5.17 The environmental testing undertaken to date was aimed at providing an exploratory (preliminary) assessment of contamination potential and it was assumed from the outset that supplementary testing may be required to further determine the risk posed. Testing identified the presence of Arsenic and organic compounds (PAH and TPH) within shallow soil samples that exceeded the relevant guideline criteria utilised (residential with plant uptake) and are discussed further below. In addition to this, significant variable and loose landfill deposits were identified in Area C which included domestic and commercial refuse and waste materials.

The levels of arsenic and some PAH compounds are elevated above the generic assessment criteria in Areas B, C and D and close to the guideline value for Area A. In addition to this, the presence of TPH compounds has been identified in Areas B, C and D.

Construction Phase

9.5.18 The construction phase of the work will require the use of mobile plant including excavating machinery, lorries, diesel generators and diesel pumps. There is a potential for the plant to leak or spill oil and or fuel. Leaks and spillages may occur in any area of the site in which the plant is operating but is most likely to occur during refuelling. Additionally, the potential exists for spills and drips to occur associated with stored chemicals brought onto the site to facilitate development. There is potential that such spillages could enter the underlying aquifer, depending on the permeability of the overlying soil and geology, and contaminate the groundwater. The effect on groundwater is considered to be of minor significance as the quantity of oil and fuel is likely to be of moderate magnitude.

9.5.18 The tracking of heavy plant across the site during construction may compact the ground surface causing an increase of runoff and a decrease in infiltration. A decrease in infiltration may lead to a reduction in local groundwater levels and therefore, a reduction in base flow to surface waters and supply to abstraction boreholes.

9.5.19 In the event that in some areas of the site contaminated material surfaces may be exposed, particularly in areas occupied by historic landfill, there is a potential for leachate both directly and indirectly from the contaminated material to the groundwater. The potential leaching of the contaminants into the groundwater may occur over a long time period.

Post Development

9.5.20 Potential longer term impacts of the redevelopment are considered to occur both as a consequence of changes to the site's character and also future use of the redevelopment.

9.5.21 In terms of hydrology, run-off from roads and parking areas potentially containing elevated levels of contaminants that could enter the water environment; however, the levels of these arising from a developed residential area are unlikely to be significant.

9.5.22 The development is to include a site specific drainage strategy that in line with current guidance will be designed to collect and manage surface water without increasing run off or overloading existing drainage systems.

9.5.23 In relation to hydrogeology, foundation construction could introduce vertical migration pathways through the superficial geology for surface contamination to impact upon the deeper groundwater regime (minor aquifer); and a reduction in the surface recharge of both shallow and deep groundwater regime due to an increase in impermeable land cover (property footprint and roadways).

9.5.24 The mitigating measures to be considered and residual impacts are discussed further in Section 9.6.

Asbestos

9.5.25 No evidence of asbestos was detected in the any of the samples submitted to the laboratory by ESP, however previous third party works identified asbestos at one location in Area B. It was advised that although no evidence has been identified in the ESP investigation, on any historic farmland such as the site, it cannot be discounted that former hollows in the site surface may have been infilled in the past, and asbestos containing materials (ACM) may have been included in the backfill materials.

Site End Uses

9.5.26 The levels of arsenic and some PAH compounds where recorded to be elevated above the generic assessment criteria in Areas B, C and D and close to the guideline value for Area A. In addition to this, the presence of TPH compounds was identified in Areas B, C and D.

The results of the testing for determinands which have been identified at levels in excess of the Generic Assessment Criteria (GAC) in at least one sample in each area, have been assessed statistically in accordance with CIEH/CL:AIRE (2008). Whilst a much large sample population will be required on an area by area basis, a summary of the preliminary statistical analysis is presented in Table 12 below and the results provide in Appendix M.

Table 2: Summary of Preliminary Statistical Analysis

Area	Exceedances Recorded For	Outcome of Preliminary Statistical Analysis
A	PAH	Outlier present and more information required.
B	Arsenic, PAH	Outliers present and more information required.
C	Arsenic, PAH, TPH	Outliers present and more information required.
D	PAH, TPH	Outlier present and more information required.

At present the limited investigation has been aimed at informing the design master plan and as part of detailed design, further testing and assessment (including statistical) should be undertaken in all Areas to determine the likely resultant risk to site end users.

Additional testing and assessment can likely be used to reduce the risk in Areas A and D, where shallow, weathered rock has been identified below the topsoil or at least zone these Areas, so that mitigating measures can be reduced/removed in some or all parts of theses areas.

In Areas B and C, we would advise that whilst additional, detailed testing is required, it is very likely that a suitable geotextile separator and clean cover system will be required in all external parts of these Areas.

Maintenance/ Construction Staff

9.5.27 It was noted that whilst the levels of potential contaminants in some areas of the site are not likely to pose a severe acute risk to construction workers or future maintenance workers, they would need to undertake their own assessment of the risks to their workers. In areas of landfill appropriate protection and decontamination measures should be put in place to ensure protection of construction and maintenance workers. In addition to the above the recommendations contained within the Health and Safety Executive Document: Protection of Workers and the General Public During the Development of Contaminated Land (HSE, 1991) should be implemented. The above precautions would be required for both construction workers during development and maintenance workers following development.

Controlled Waters

9.5.28 Groundwater monitoring has shown that water in the landfill (Area C) and underlying bedrock is at a similar level, suggesting it is in continuity with the nearby groundwater within the bedrock. The landfill was found to have no lining and water (with contamination loading) will

therefore be able to pass from the landfill into the surrounding bedrock, and thus, the local groundwater body with the landfill will essentially act as a 'bowl', or 'colander' and if it is unlined, groundwater level within the landfill will be similar to that in the surrounding soils or rock.

9.5.29 Groundwater monitoring has shown that groundwater is expected to flow from the eastern parts of the site, through the landfill toward the western parts of the site, eventually on to Sully Brook, which is likely to be an effluent stream. Thus, contamination in the groundwater will flow toward the west, toward Sully Brook.

9.5.30 The groundwater table in the far eastern parts of the site is anticipated to fall toward the east, toward the sea cliffs and away from contamination sources.

9.5.31 The investigation and monitoring programme has enabled us to develop a confident ground model such that the risks posed to receptors is well understood, and essentially quantifiable, with samples collected from all borehole installations over multiple visits. This has included a series or boreholes at the west boundary of the site and closest to the Sully Brook. Groundwater test results have been compared to relevant guideline criteria (EQS, PCV or UKTAG dependant on determinand) and these have generally been observed to decrease down gradient such that risks to receptors are generally considered to be low.

Groundwater testing has shown levels of copper in all Areas (A to D) and these are considered to be natural or background concentrations. The levels of copper show no obvious decrease in concentration further from Areas B and C and they have been recorded up gradient of the anticipated source.

Visit 1 monitoring showed metals including nickel, cadmium, zinc and chromium to be elevated in samples taken from Areas B and C, and generally appear to be higher in Area C. These metals are not noted in any other water samples taken from Area A or D, during Visit 1.

Visit 2 showed metals such as cadmium, nickel, copper, zinc and chromium to be elevated in Areas B and C only, the concentrations of such metals are generally higher in Area C. Arsenic is elevated (UKTAG) in Area C only. Elevated concentrations (against EQS) of Fluoranthene and Anthracene was elevated (EQS and UKTAG) in Area C during both visits, but not elevated elsewhere. Other polyaromatic hydrocarbons (PAH), such as benzo(a)pyrene were noted to be elevated (PCV) during visit 2.

The groundwater testing showed that elevated concentrations of nickel, zinc, cadmium, chromium, benzo(a)pyrene, anthracene, fluoranthene and Sum PAH needed further consideration and a level 3 controlled groundwater risk assessment was undertaken to better understand these risks to the receptor for the assessment (water in Sully Brook).

The remedial target concentrations (RTCs) derived from the Level three assessment show that nickel, zinc, chromium and benzo(a)pyrene present a theoretical risk to Sully Brook, whilst cadmium, anthracene, fluoranthene and sum PAH do not pose a risk to Sully Brook. The sensitivity analysis has shown that doubling the gradient, and permeability, has no impact on the remediation target concentrations for nickel, cadmium, zinc, chromium and benzo(a)pyrene.

However, the sensitivity analysis did show the remedial target concentrations for anthracene, fluoranthene and sum PAH to alter, however, these were to very high concentrations which have not been measured in the investigation.

The concentrations of contaminants anticipated to be leaving site are at such low levels, no current technology exists that could provide significant or meaningful betterment or treatment. The removal of the source, thought to be Area C and the wider landfill (off site) is

unlikely to be economically viable for the development. If further confidence on the above is required, then further monitoring could be carried out in due course, which could coincide with investigation of nearby land, including the landfill and the quarry (Area E).

Discussion of Encountered Geotechnical Conditions

Foundations and Floor Slabs

9.5.32 The available information collated during the assessment identified that in Areas A and D, mass concrete foundations could be utilised, placed in the more competent bedrock, encountered at shallow depth beneath the site. In Area B piled foundations were recommended, with this extended to include Area C, should any future development in this area be proposed.

9.5.33 Due to highly plastic near surface weathered soils in Areas A and D and Made Ground in areas B and C, the use of ground bearing floor slabs could not be recommended and floor slabs should be suspended or combined into a raft foundation. Should shallow competent (fresh) rock be encountered, it may be feasible to utilise ground bearing floor slabs and this should be reviewed as part of detailed design on an area by area basis.

Concrete Classification

9.5.32 A preliminary assessment of concrete classification was undertaken as part of the assessment which indicated the following:

- Area A – Available information for Area A, suggests the site is classified between Sulphate Class DS-2 and Aggressive Chemical Environment for Concrete Class AC-2 and DS-3/AC3.
- Area B – Available information for Area B, suggests the site is classified between Sulphate Class DS-2 and Aggressive Chemical Environment for Concrete Class AC-2.
- Area D – Available information for Area D, suggests the site is classified between Sulphate Class DS-2 and Aggressive Chemical Environment for Concrete Class AC-2.
    - Further detailed testing and assessment would be required on an Area by Area basis to further refine the sulphate risk and concrete classification particularly in Area A. however, at this stage an allowance should be made for an advanced concrete class.
- As Area C is anticipated to comprise Public Open Space, a classification of sulphate attack has not been undertaken at present. Should this requirement change a detailed assessment of the potential for sulphate attack will be required through the landfill material, however, it is anticipated an advanced concrete class would be required in Area C.

Sustainable Drainage

9.5.33 A series of soakaway infiltration and falling head testing has been undertaken at the site in Areas A and D in order to provide preliminary design information for sustainable drainage. Due to the extensive Made Ground and Landfill materials encountered in Areas B and C, no shallow testing has been carried out, in order to avoid the mobilisation of contaminants, however, 2no. falling head tests have been undertaken in rotary boreholes within the bedrock, below the aquifer protection measures. Whilst one successful soakaway infiltration test was recorded in Area D, generally poor infiltration rates have been recorded. The fine weathered bedrock is likely to retard the permeability of the shallow soils and due to the shallow bedrock encountered beneath Areas A and D, fracture flow is likely to dictate permeabilities, which may vary significantly across the site.

Cliff Inspection

9.5.34 As part of the works, a cliff inspection was undertaken to determine the potential for the development to be affected by cliff collapse. The full assessment of this is provided in our report and this should be referred to (Ref: 7061b.3166 Rev2).

9.5.35 A commonly observed and adopted rule for regression-rate of the Vale of Glamorgan coastline is approximately 1m per 30years. Whilst increases in sea level and storminess are forecast owing to global changes in climate, this rate is considered appropriate for reasoned decision making. We recommended that any critical infrastructure be kept a minimum of 10m from the cliff edge, and consideration be given to adopting the same building-line as used in developments to the north, whereby private properties are stepped back further from the cliff by positioning the access roads on the seaward side.

GEOENVIRONMENTAL MITIGATION MEASURES AND RESIDUAL IMPACTS

9.6 The main mitigation measure to prevent adverse impacts on soils, geology and hydrogeology, during all phases of the development is to ensure good site practice and management. The site management practices should be undertaken in accordance with the following Environment Agency Pollution Prevention Guidelines:

- PPG 1 – General guide to the prevention of pollution;
- PPG 2 – Above ground oil storage tanks;
- PPG 6 – Working at construction and demolition sites;
- PPG 7 – Refuelling facilities;
- PPG 8 – Safe storage and disposal of used oils;
- PPG 18 – Managing fire water and major spillages;
- PPG 21 – Pollution incidence response planning; and
- PPG 26 - Storage and Handling of Drums and Intermediate Bulk Containers.

9.6.1 Additionally, Site Environmental Rules should be established through an Environmental Management Plan (EMP) for the construction phase and followed at all times throughout the contract. The following measures should also be considered.

9.6.2 A watching brief should be maintained during construction works and where contamination is identified or suspected, appropriate sampling, analysis and risk assessment should be undertaken and suitable measures put in place to prevent the creation of pollutant linkages. Implementation of these simple measures can reduce the impacts to construction workers and adjacent site users from potentially contaminated dusts.

9.6.3 All vehicles leaving the site should go through a wheel wash to prevent spreading of detritus onto off-site roads. Furthermore, vehicles carrying soils off-site should only to be loaded up to appropriate levels and be covered to prevent conditioned sediments dropping onto roads.

9.6.4 Potential ground gas at the site may be mitigated by incorporating gas protection measures into building designs. However better knowledge of the gas regime is needed to determine if ground gas protection measures are needed.

9.6.5 Any potential effects of ground contamination on building materials should be identified and taken into consideration at the building design stage, for example, the foundations of the buildings should be designed in accordance with BRE guidance Special Digest 1: 2005 'Concrete in Aggressive Ground'.

9.6.6 Any water pipes placed at the site should be constructed from a suitable material to resist hydrocarbon attack from contaminants which may be present in the ground, and surrounded with a suitable clean gravel fill, in accordance with recommended guidance.

9.6.7 All surface water and process water should be treated, for example, through the use of oil interceptors etc. before being discharged to the ground or surface water.

9.6.8 A detailed summary of residual impacts, following implementation of the mitigation measures identified in the assessment, and their significance, is provided below in Tables 3 and 4.

Table 3 Residual Impact Summary Table – Soils and Geology

Development Phase	Description of Potential Impact	Assessment of Significance Without Mitigation	Proposed and Recommended Mitigation Measures	Residual Impact
Construction	Operation of moving or stationary plant - Oil/ fuel spills and drips from plant during operation and refuelling onto site soils	Medium	Good site management practices should be undertaken in accordance with Environment Agency Pollution Prevention Guidelines. Site Environmental Rules should be established through an EMP for the construction phase and followed at all times.	Medium/Small Not Significant
	Storage of hazardous materials - Construction chemicals from spills and drips, and during failure of containers onto site soils	Medium	Good site management practices should be undertaken in accordance with Environment Agency Pollution Prevention Guidelines. Site Environmental Rules should be established through an EMP for the construction phase and followed at all times.	Medium/Small Not Significant
	Vehicles cross the site - Tracking of contaminated materials across the site	Medium	No on site ground contamination identified. However, All vehicles leaving site are to go through a wheel wash to prevent spreading of contamination onto off-site roads.	Medium/Small Not Significant
	Excavation of soils - exposure of construction workers to contaminants at depth.	Medium	Some potentially contaminative compounds identified, however, use of PPE and good hygiene practises, to ensure that health and safety risks are minimised during construction.	Medium/Small Not Significant

Construction	Excavations in confined spaces - Exposure of construction workers to ground gases	High	Monitoring is ongoing with this aspect to be confirmed. Use of PPE and appropriate definition of confined spaces, to ensure that health and safety risks are minimised during construction.	High/Moderate Moderately Significant
	Creating additional pathways for the migration of landfill gas, with consequent increased risk of explosion.	High	Monitoring is ongoing with this aspect to be confirmed. Working procedures would include a requirement for gas monitoring to be carried out before personnel enter any excavations. Smoking would be restricted in the vicinity of excavations. Impermeable membranes would be incorporated into the building designs to prevent gas entry.	High/Moderate Moderately Significant
	Disturbance of potentially contaminated soils -mobilisation of contaminants to site soils and construction workers	Medium	Use of PPE and good hygiene practises, to ensure that health and safety risks are minimised during construction.	Medium/Moderat e Slightly Significant
Construction	Stockpiling of excavated soils - Migration of contaminants through dust generation and leaching	Medium	Dust suppression measure should be implemented e.g. impermeable covers spread over mounds of bare soil and wetting of bare soil during dry conditions.	Medium/Moderat e Slightly Significant
	On site reuse of contaminated soils – Exposure of construction workers and adjacent users to contaminated dusts	Medium	Dust suppression measure should be implemented e.g. impermeable covers spread over mounds of bare soil and wetting of bare soil during dry conditions.	Medium/Moderat e Slightly Significant

Construction	Encountering unforeseen contamination, not identified during the site investigation, in excavations for foundations or services and spreading this contamination, either to clean areas within the site.	Medium	Site staff would be briefed to ensure that all excavations are regularly inspected to provide an early indication of unforeseen areas of contamination, which, through excavation and movement of materials within or off the site, could spread contamination.	Medium/Moderate Slightly Significant
	Offsite removal of contaminated soils - permanent removal of some contaminated soils from the site	Medium	Some areas of the site likely to be affected by potentially contaminated compounds and disposal options are to be considered.	Medium/Moderate Slightly Significant
	Unintentional import of contaminated materials as fill e.g. to increase ground levels and as necessary within the amenity and landscape areas of the site.	Medium	Any secondary materials would be analysed for the presence of total and leachable contaminants before being brought to site, to ensure that it presents no significant risk of contamination to soils, groundwater or controlled waters..	Medium/Small Not Significant
	Storage of potentially contaminated groundwater - Contaminated water leaking onto uncontaminated soils	Medium	Good site management practices should be undertaken in accordance with Environment Agency Pollution Prevention Guidelines. Site Environmental Rules should be established through an EMP for the construction phase and followed at all times.	Medium/Small Not Significant

Occupation	Daily use of the site – Pollutant linkages between contaminated soils and landscape areas	Medium	Use of protective cover system has been recommended in areas of the site in order to protect site end users.	Medium/Moderate Slightly Significant
	Daily use of the site - Build up of ground gas within confined spaces and buildings	High	Monitoring is ongoing with this aspect to be confirmed. Definition of confined spaces will be required and where necessary incorporate gas protection measures into building designs.	Medium/Moderate Slightly Significant
	Below ground building materials and structures - Aggressive chemical attack by sulphate on building materials.	Small	Any potential effects of ground contamination on building materials should be identified and taken into consideration at the building design stage.	Medium/Small Not Significant
	In-ground water pipes - Chemical attack on water pipes and potential contamination of water supply.	Medium	Any water pipes placed at the site should be constructed from a suitable material to resist chemical attack from contaminants present in the ground, and surrounded with a suitable clean gravel fill, in accordance with WRAS guidance.	Medium/Small Not Significant
	Service trenches - Migration of contaminants along trenches to uncontaminated soils	Medium	Placement of suitable bunds e.g. clay around pipes	Medium/Small Not Significant

	Surface water runoff from roads and car parks – Spillages and leaks of oil/fuel entering soils directly or via runoff	Medium	Design of drainage system to remove contaminants.	Medium/Small Not Significant

Table 4 Residual Impact Summary Table - Hydrogeology

Development Phase	Description of Potential Impact	Assessment of Significance Without Mitigation	Proposed and Recommended Mitigation Measures	Residual Impact
Construction	Operation of moving plant - Oil/ fuel spills and drips from plant during operation and refuelling directly entering groundwater	Small	Good site management practices should be undertaken in accordance with Environment Agency Pollution Prevention Guidelines. Site Environmental Rules should be established through an EMP for the construction phase and followed at all times.	Medium/Small Not Significant
	Storage of hazardous materials - Construction chemicals from spills and drips, and during failure of containers directly entering groundwater	Small	Good site management practices should be undertaken in accordance with Environment Agency Pollution Prevention Guidelines. Site Environmental Rules should be established through an EMP for the construction phase and followed at all times.	Medium/Small Not Significant
	Tracking of vehicles - Compaction of ground surface, increasing run off and decreasing infiltration	Small	Good site management practices should be undertaken in accordance with Environment Agency Pollution Prevention Guidelines. Site Environmental Rules should be established through an EMP for the construction phase and followed at all times.	Medium/Small Not Significant

Construction	Disturbance of potentially contaminated soils - Leaching of contaminants both directly and indirectly from contaminate material into groundwater.	Medium	Good site management practices should be undertaken in accordance with Environment Agency Pollution Prevention Guidelines	Low/Negligible Not Significant
	Dewatering of ground to provide dry working conditions - Reduction of local groundwater levels, reducing base flow to surface water, and potentially inducing settlement below structures	Small	Monitoring has indicated generally dry shallow ground conditions, Should groundwater be identified at shallow depth, mitigation measures to control groundwater around the excavation, and subsequent discharge to controlled waters.	Medium/Small Not Significant
	Runoff of silty water from materials stockpiles and roadways	Medium	Excavated soils would be stockpiled clear of any water course to minimise the potential for silty runoff in wet weather. Road sweeping would be carried out as necessary, to remove deposits of silt from roads and therefore prevent its migration into gullies and hence controlled waters.	Low/Negligible Not Significant
Occupation	Surface water runoff from roads and car parks – Spillages and leaks of oil/fuel entering groundwater directly or via runoff	Medium	Design of drainage system to remove contaminants before discharge to controlled waters.	Medium/Small Not Significant

	Construction of piled foundations – Migration of contaminants within the ground into the underlying groundwater and controlled waters	Medium	Piled foundations likely required in some areas of the site and will require a piling risk assessment in line with EA requirements, however, piling is not anticipated to be used in the most contaminated areas of the site where no development is proposed (former landfill).	Medium/Small Not Significant

SUMMARY AND CONCLUSIONS

9.7 It is understood that this investigation, inclusive of preliminary laboratory testing was required to obtain sufficient information to inform a Masterplan, mitigate risk, address statutory planning requirements and provide recommendations for further investigation and assessment in areas of the site as necessary.

9.7.1 The levels of arsenic and some PAH compounds are elevated above the generic assessment criteria in Areas B, C and D and close to the guideline value for Area A. In addition to this, the presence of lighter band TPH compounds has been identified in Areas B, C and D. Additional testing and assessment can likely be used to reduce the risk in Areas A and D, where shallow, weathered rock has been identified below the topsoil or at least zone these Areas, so that mitigating measures can be reduced/removed in some or all parts of theses areas. In Areas B and C, we would advise that whilst additional, detailed testing is required, it is very likely that a suitable geotextile separator and clean cover system will be required in all external parts of these Areas.

9.7.2 Groundwater monitoring has shown that although testing has shown slightly elevated levels of contaminants at the site, when compared with pertinent guideline values (DWS, PCV and/or UKTAG), these have generally been observed to decrease down gradient such that risks to receptors are generally considered to be low. The concentrations of contaminants anticipated to be leaving site are at such a low levels, no current technology exists that could provide significant or meaningful betterment or treatment. The removal of the source, thought to be Area C and the wider landfill (off site) is unlikely to be economically viable for the development.

9.7.3 Potential impacts have been identified during both the construction, and post occupation phases of the proposed development. Many, if not all, of the construction impacts can be substantially reduced or removed by adherence to good site practice. A number of occupational phase impacts are likely to create residual impacts and by implementing proposed mitigation measures these impacts should be kept to a minimum.

9.7.4 The mitigation measures outlined above would minimise the potential for construction operations to contaminate soils and controlled waters. These measures would be incorporated into a Pollution Prevention or Construction Management Plan, prepared by the

appointed contractor and agreed with EAW and the LPA prior to commencement of construction.

9.7.5 A number of conclusionary works are being progressed by ESP, such as ground gas monitoring etc. and the above risk drives and outcomes, should be reviewed on completion of these works.

ATTACHMENT A - RISK EVALUATION METHODOLOGY

The methodology set out in CIRIA C552 (2001), *Contaminated Land Risk Assessment – A Guide to Good Practice*, has been used to assess whether or not risks are acceptable, and to determine the need for collating further information or remedial action. The following tables have been used to classify the risk for each pathway. Tables A2 to A4 have been revised to include for circumstances where no plausible risk has been identified.

Table A1 - *Classification of Consequence*

Classification	Definition	Examples
Severe	• Short-term (acute) risk to human health likely to result in *Significant Harm*. • Short-term risk of pollution to a sensitive water resource. • Catastrophic damage to buildings/property. • Short-term risk to ecosystem, or organism forming part of that ecosystem.	• High concentrations of Cyanide at surface of informal recreation area. • Major spillage of contaminants from site into controlled water. • Explosion causing building collapse.
Medium	• Chronic damage to human health. • Pollution of sensitive water resource. • A significant change to ecosystem, or organism forming part of that ecosystem.	• Contaminant concentrations exceed assessment criteria. • Leaching of contaminants to Secondary A aquifer. • Death of species within nature reserve.
Mild	• Pollution of non-sensitive water resources. • Significant damage to crops, buildings, structures. • Damage to sensitive buildings, structures or the environment.	• Pollution of Secondary groundwater sources. • Damage to building rendering it unsafe to occupy.
Minor	• Harm, although not necessarily significant harm, which may result in financial loss, or expenditure to resolve. • Non permanent risks to human health (easily prevented by means of PPE). • Easily repairable effects of damage to buildings and structures.	• The presence of contaminants at such concentrations that PPE is required during site works. • The loss of plants in a landscaping scheme. • Discoloration of concrete.

Table A2: *Classification of Probability*

Classification	Definition
High Likelihood	There is a pollutant linkage and an event that either appears very likely in the short term and almost inevitable over the longer term. Or, there is already evidence at the receptor of harm or pollution.
Likely	There is a pollution linkage and all the elements are present and in the right place, which means that it is probable that an event will occur. Circumstances are such that an event is not inevitable, but possible in the short term and likely over the longer term.
Low Likelihood	There is a pollutant linkage and circumstances are possible under which an event could occur. However, it is by no means certain that even over a longer period such an event would take place, and is less likely in the shorter term.

Unlikely	There is a pollutant linkage, but circumstances are such that it is improbable that an event would occur, even in the very long term.
No Linkage	No plausible linkage has been established.

Table A3*: Risk Categories – Comparison of consequence against probability*

		Consequence			
		Severe	**Medium**	**Mild**	**Minor**
Probability	**High Likelihood**	Very High Risk	High Risk	Moderate Risk	Moderate / Low Risk
	Likely	High Risk	Moderate Risk	Moderate / Low Risk	Low Risk
	Low Likelihood	Moderate Risk	Moderate / Low Risk	Low Risk	Very Low Risk
	Unlikely	Moderate / Low Risk	Low Risk	Very Low Risk	Very Low Risk
	No Linkage	No Risk			

Table A4: *Description of Risk Categories*

Classification	**Description**
Very High Risk	• There is a probability that severe harm could arise to a designated receptor from an identified hazard. Or, there is evidence that severe harm to a designated receptor is currently happening. • The risk, if realised, is likely to result in a substantial liability. • Urgent investigation (if not already undertaken) and remedial action are likely to be required.
High Risk	• Harm is likely to arise to a designated receptor from an identified hazard. • Realisation of the risk is likely to present a substantial liability. • Urgent investigation (if not already undertaken) is required, and remedial action may be necessary in the short term and are likely over the longer term.
Moderate Risk	• It is possible that harm could arise to a designated receptor from an identified hazard. However, it is either relatively unlikely that any such harm would be severe, or if any harm were to occur, it is more likely that the harm would be mild. • Investigation (if not already undertaken) is normally required to clarify the risk and to determine potential liability. Some remedial action may be required in the longer term.
Low Risk	• It is possible that harm could arise to a designated receptor from an identified hazard, but it is likely that this harm, if realised, would at worst normally be mild.
Very Low Risk	• There is a very low possibility that harm could arise at a receptor. In the event of such harm being realised, it is not likely to be severe.
No Risk	• No risk mitigation required.

ATTACHMENT B – PRELIMINARY/PLAUSIBLE RISK EVALUATION METHODOLOGY

Preliminary/Plausible Risk Evaluation & Relevant Pollutant Linkages (RPL) – Areas A and D (Extracted from ESP Report 7061b.3166 Rev2)

Source	Pathway	Receptor	Classification of Consequence	Classification of Probability	Risk Category	Further Investigation/ Remedial Action
Potential contaminants in shallow soils (see Section 3.1.2)	Direct contact/ inhalation/ ingestion of contaminated soil or dust	Site Users (residents)	Medium – potential for chronic levels.	Likely[2]	Moderate	Sampling and testing required (and addressed as part of this scope of works).
	Direct contact/ inhalation/ ingestion of contaminated soil or dust	Construction/ Maintenance Workers	Minor/Medium – standard PPE likely to be sufficient	Likely[2]	Moderate/Low Risk	
	Leaching of soil contaminants	Impact on Groundwater	Medium – site lies on Secondary A and B Aquifer	Likely[2]	Moderate	Sampling and testing required with initial assessment of risk to Controlled Waters.
	Leaching of soil contaminants	Impact on Sully Brook	Medium – site lies adjacent to water course	Likely[2]	Moderate	
Asbestos in shallow soils	Ingestion of fibres	Construction/ Maintenance Workers	Medium – potential for chronic levels	Low Likelihood[3]	Moderate/Low Risk	Sampling and testing required.
Soil sulphate/ pyrite	Aggressive groundwater	Buried Concrete	Mild – damage to structures	High likelihood[4]	Moderate Risk	Sampling and testing required.
Hazardous ground gas/vapours, from gas migration from infilled land and landfill (see Section 3.1.3).	Asphyxiation/poisoning. Injury due to explosion.	Site Users/Visitors.	Severe – acute risk.	Likely[5]	High Risk	Ground gas monitoring and assessment to be implemented.
	Damage through explosion.	Building/Property	Severe – acute risk.		High Risk	
	Asphyxiation/poisoning. Injury due to explosion.	Construction and Maintenance Workers.	Severe – acute risk.		High Risk	
Radon gas (see Section 3.1.4)	Migration into Buildings	Site Users (residents)	Medium – potential for chronic levels	Low Likelihood	Low Risk	Nc protection required as reported by Arcadis Desk Study

Notes:

1. This table represents ESP assumptions and recommendations based on a review of previously undertaken Arcadis works
2. Limited Made Ground identified and further confidence required.
3. Due to age of buildings on site, potential for buried asbestos on farmland.
4. Preliminary assessment of soil sulphate to be undertaken.
5. Ground gas potential as a result of migration from adjoining infilled land (Area B) and landfill (Area C).

Preliminary/Plausible Risk Evaluation & Relevant Pollutant Linkages (RPL) – Areas B and C (Extracted from ESP Report 7061b.3166 Rev2)

Source	Pathway	Receptor	Classification of Consequence	Classification of Probability	Risk Category	Further Investigation/ Remedial Action
Potential contaminants in shallow soils (see Section 3.1.2)	Direct contact/ inhalation/ ingestion of contaminated soil or dust	Site Users (residents)	Medium – potential for chronic levels.	High Likelihood[2]	High Risk	Sampling and testing required (and addressed as part of this scope of works).
	Direct contact/ inhalation/ ingestion of contaminated soil or dust	Construction/ Maintenance Workers	Minor/Medium – standard PPE likely to be sufficient	High Likelihood[2]	High Risk	
	Leaching of soil contaminants	Impact on Groundwater	Medium – site lies on Secondary A and B Aquifer	High Likelihood[2]	High Risk	Sampling and testing required with initial assessment of risk to Controlled Waters.
	Leaching of soil contaminants	Impact on Sully Brook	Medium – site lies adjacent to water course	High Likelihood[2]	High Risk	
Asbestos in shallow soils	Ingestion of fibres	Construction/ Maintenance Workers	Medium – potential for chronic levels	Likely[3]	Moderate/ High Risk	Sampling and testing required.
Soil sulphate/ pyrite	Aggressive groundwater	Buried Concrete	Mild – damage to structures	High likelihood[4]	Moderate Risk	Sampling and testing required.
Hazardous ground gas/vapours, from gas migration from infilled land and landfill (see Section 3.1.3)	Asphyxiation/poisoning. Injury due to explosion.	Site Users/Visitors.	Severe – acute risk.	High Likelihood [5]	Very High Risk	Ground gas monitoring and assessment to be implemented.
	Damage through explosion.	Building/Property	Severe – acute risk.			
	Asphyxiation/poisoning. Injury due to explosion.	Construction and Maintenance Workers.	Severe – acute risk.			
Radon gas (see Section 3.1.4)	Migration into Buildings	Site Users (residents)	Medium – potential for chronic levels	Low Likelihood	Low Risk	Nc protection required as reported by Arcadis Desk Study

Notes:

1. This table represents ESP assumptions and recommendations based on a review of previously undertaken Arcadis works
2. Potential for significant Made Ground in Area B and Landfill materials in Area C - further confidence required.
3. Due to age of buildings on site, potential for buried asbestos on farmland and identification of asbestos in Area B by Arcadis.
4. Preliminary assessment of soil sulphate to be undertaken.
5. Ground gas potential as a result of generation from infilled land (Area B) and landfill (Area C). Arcadis reports note >30% Methane.

ATTACHMENT C – PLAUSIBLE/RESULTANT RISK EVALUATION METHODOLOGY

Plausible/Resultant Risk Evaluation & Relevant Pollutant Linkages (RPL) – Areas A and D

Source	Pathway	Receptor	Classification of Consequence	Classification of Probability	Risk Category	Further Investigation/ Remedial Action
Potential contaminants in shallow soils	Direct contact/ inhalation/ ingestion of contaminated soil or dust	Site Users (residents)	Medium – potential for chronic levels.	Likely	Moderate	Arsenic and PAH compounds identified close to or just above guideline values, with further assessment required.
	Direct contact/ inhalation/ ingestion of contaminated soil or dust	Construction/ Maintenance Workers	Minor/Medium – standard PPE likely to be sufficient	Likely	Moderate/Low Risk	Arsenic and PAH compounds identified close to or just above guideline values, but likely to be managed by good site practice.
	Leaching of soil contaminants	Impact on Groundwater	Medium – site lies on Secondary A and B Aquifer	Likely[1]	Moderate	Ongoing monitoring and sampling of groundwaters with initial assessment of risk to Controlled Waters.
	Leaching of soil contaminants	Impact on Sully Brook	Medium – site lies adjacent to water course	Likely[1]	Moderate	
Asbestos in shallow soils	Ingestion of fibres	Construction/ Maintenance Workers	Medium – potential for chronic levels	Low Likelihood	Moderate/Low Risk	Not detected in samples submitted to laboratory.
Soil sulphate/ pyrite	Aggressive groundwater	Buried Concrete	Mild – damage to structures	High likelihood	Moderate Risk	Sulphate classification indicates an advanced concrete classification may be required. .
Hazardous ground gas/vapours, from gas migration from infilled land and landfill.	Asphyxiation/poisoning. Injury due to explosion.	Site Users/Visitors.	Severe – acute risk.	Likely[2]	High Risk	Ground gas monitoring ongoing and to be reported as an addendum.
	Damage through explosion.	Building/Property	Severe – acute risk.		High Risk	
	Asphyxiation/poisoning. Injury due to explosion.	Construction and Maintenance Workers.	Severe – acute risk.		High Risk	
Radon gas	Migration into Buildings	Site Users (residents)	Medium – potential for chronic levels	Low Likelihood	Low Risk	Nc protection required as reported by Arcadis Desk Study

Notes:

1. Groundwater monitoring is ongoing and a preliminary assessment of risk to Controlled Waters is to be provided.
2. Ground gas monitoring is ongoing.

Plausible/Resultant Risk Evaluation & Relevant Pollutant Linkages (RPL) – Areas B and C

Source	Pathway	Receptor	Classification of Consequence	Classification of Probability	Risk Category	Further Investigation/ Remedial Action
Potential contaminants in shallow soils including biological contaminants in landfill materials in Area C.	Direct contact/ inhalation/ ingestion of contaminated soil or dust	Site Users (residents)	Medium – potential for chronic levels.	High Liklihood[2]	High Risk	Arsenic, PAH and TPH compounds identified above guideline values, with further assessment required.
	Direct contact/ inhalation/ ingestion of contaminated soil or dust	Construction/ Maintenance Workers	Minor/Medium – standard PPE likely to be sufficient	High Liklihood[2]	High Risk	Protection of workers will need to be considered in detail, particularly in Area C.
	Leaching of soil contaminants	Impact on Groundwater	Medium – site lies on Secondary A and B Aquifer	High Liklihood[2]	High Risk	Ongoing monitoring and sampling of groundwaters with initial assessment of risk to Controlled Waters.
	Leaching of soil contaminants	Impact on Sully Brook	Medium – site lies adjacent to water course	High Liklihood[2]	High Risk	
Potential contaminants including biological within anecdotally recorded area of cattle pyre	Direct contact/ inhalation/ ingestion of contaminated soil or dust	Site Users (residents)	Medium – potential for chronic levels.	Likely	Moderate	Evidence is anecdotal, however, area not investigated during this phase of works and will require future consideration.
	Direct contact/ inhalation/ ingestion of contaminated soil or dust	Construction/ Maintenance Workers	Medium – standard PPE likely to be sufficient	Likely	Moderate Risk	
Asbestos in shallow soils	Ingestion of fibres	Construction/ Maintenance Workers	Medium – potential for chronic levels	Likely[3]	Moderate/ High Risk	Not detected in samples submitted to laboratory by ESP but identified in Area B by Arcadis.
Soil sulphate/ pyrite	Aggressive groundwater	Buried Concrete	Mild – damage to structures	High likelihood[4]	Moderate Risk	Sulphate classification indicates an advanced concrete classification may be required. .
Hazardous ground gas/vapours, from gas migration from infilled land and landfill.	Asphyxiation/poisoning. Injury due to explosion.	Site Users/Visitors.	Severe – acute risk.	High Likelihood [5]	Very High Risk	Ground gas monitoring ongoing and to be reported as an addendum.
	Damage through explosion.	Building/Property	Severe – acute risk.			
	Asphyxiation/poisoning. Injury due to explosion.	Construction and Maintenance Workers.	Severe – acute risk.			
Radon gas	Migration into Buildings	Site Users (residents)	Medium – potential for chronic levels	Low Likelihood	Low Risk	Nc protection required as reported by Arcadis Desk Study

Notes:

1. Groundwater monitoring is ongoing and a preliminary assessment of risk to Controlled Waters is to be provided.
2. Ground gas monitoring is ongoing.